

CURRENTS AND RELATED PROBLEMS AT
METROPOLITAN BEACH, LAKE ST. CLAIR

John C. Ayers

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SUMMARY AND CONCLUSIONS

1. The wind regime at Metropolitan Beach is adequately represented by that at Selfridge Air Force Base.
2. The observed winds at the Beach in the summers of 1962 and 1963 were "atypical" when compared to the long-term norms.
3. August of 1962 was a month with unusually frequent winds from the southeast, accounting for the unusually good water quality of the month.
4. The alongshore currents at the Beach are westward under winds from the north, northeast, east, and southeast; they are eastward under southwest, west, and northwest winds.
5. The opening of Southeast Bend Cutoff Channel in St. Clair Flats appears to have increased the proportion of St. Clair River water arriving directly into the main lake basin. The contribution of St. Clair River water to Anchor Bay through North Channel has apparently been somewhat diminished by the opening of the Cutoff Channel. The outflow of the Clinton River appears to circulate through Anchor Bay somewhat more readily than it did prior to the new channel.
6. A system of deflectors capable of making flotsam by-pass the bathing area of Metropolitan Beach under southwest winds has been found. It is doubted that the system is economically feasible.
7. A series of studies indicates that the proposed West Boat Lagoon may be expected to be free of sanding-in difficulties if modification in placement of channels is made.
8. The grey "ooze" that settles on the bathing beach in calm weather is apparently a modified erosion product of a local bottom clay horizon.
9. Needed background information on the conductivity, residue-on-evaporation, and chemical nutrient levels has been gathered.
10. Water-quality at Metropolitan Beach is under the control of a complex consisting of local poor-water sources, winds, and alongshore currents. The one water source for which data are available, Black Creek, seems to be deteriorating in quality.

INTRODUCTION

This study of currents and related problems at Metropolitan Beach stemmed from specific nuisance problems of 1) flotsam arriving under southwest winds on the bathing beach at Metropolitan Beach in Macomb County, 2) a grey "ooze" which in calm periods settles from the water in the bathing area, and 3) migration of littoral sand bars which might interfere with the channel(s) from a proposed new boat lagoon at the west end of the Metropolitan Beach property.

The basic phenomena underlying all three of the specific problems are 1) the alongshore water-currents (which deliver flotsam and ooze and which are the transporting medium of the littoral sand transport), 2) the currents of Lake St. Clair outside the immediate area of the Beach (which feed both water and extraneous materials into the alongshore currents), and 3) the winds that provide driving force for both sets of currents.

The opening of the Southeast Bend Cutoff of the St. Clair River South Channel in the spring of 1962 introduced the possibility that the currents of Lake St. Clair might be modified by re-direction of the local St. Clair River outflow. This possibility was investigated because it might bring the better-quality St. Clair River water nearer to the Beach than was formerly the case.

METHODS

Currents being basic to the problems, much work was done on the determination of current patterns under various wind conditions.

In the study of alongshore currents at the Beach, it was necessary to obtain a large series of observations. To this end a combination wind-and-current recording station was installed at the west end of the bathing-beach area. This station recorded eight wind directions, two scales of wind velocity, and eight directions of alongshore water current. These data established the current directions that accompany each wind direction. They also gave information on the relation of each month's winds to the long-time mean winds.

Current-cross (drogue) studies of currents in the immediate area of the Beach were carried out to verify the wind and current data being recorded at the automatic station.

The wind instruments of the recording station were a standard heavy-duty anemometer and wind vane coupled to an Esterline-Angus operations recorder. The current indicator consisted of an inverted pendulum attached to a heavy base lying on the lake bottom about 300 feet from shore. The pendulum stood erect in the water as a result of styrofoam flotation in its upper end. In the base of the pendulum four mercury switches oriented to the four main directions were so mounted that current-induced tilt of the pendulum would cause contacts to be made and current direction to be indicated on the operations recorder. Under westward current for example, only the "west" switch would make contact; under south-

westward current both "south" and "west" switches would make contact and both directions would be recorded.

In the final studies of possible flotsam deflectors and of details of the alongshore current, a hydrographic model of the Huron Point region was made. This was a distorted Fronde model with horizontal scale of 1: 10,000 and vertical scale of 1 : 16 and covered the region from about Harrison Road to east of Huron Point. An electric fan was used to simulate wind.

In the study of the currents of Lake St. Clair a hydrographic model of the whole lake was used. This was a distorted Fronde model with horizontal scale of 1 : 60,000 and vertical scale of 1 : 1,000. The interior of the modelled delta of the St. Clair River was excavated in order to provide a stilling basin to quiet the feed-water simulating the inflow of the St. Clair River. From the stilling basin the channels of Chenal Ecarte, Johnston Channel, South Channel, Middle Channel, and North Channel opened to the body of the lake. At the lower end of the model the Detroit River opened, below Peach Island, into a second stilling basin whose outlet was adjusted to the scaled depth of the Detroit River.

Wind over the lake model was simulated by a linear "wind horn." Compressed air was led into the ends of a 6-foot plastic pipe, 2" in diameter, along one side of which a line of small holes was drilled. From the middle of the pipe a connection lead to a U-tube manometer. The plastic pipe was mounted in a horizontal venturi box in such way that air flowed from the line of holes and through the venturi, entraining additional air from around the plastic pipe. A horizontal flow-smoothing plate was

mounted in the venturi. Winds from the various directions were simulated by moving the wind horn to various positions on the table around the model.

The model was surrounded by a large masonite table surface 1/2 inch above water level. A fairing of modelling clay made a streamlined connection from the table surface to the modelled beach. The model was operated with detergent added to the feed-water to reduce capillary effects, and with aqueous-alcoholic solutions of food coloring to mark the outflows of the Clinton River, the St. Clair River, and the Chenal Ecarte-Johnston Channel combination.

After preliminary runs of the model under different directions of wind, our research vessel NAIAD was sent to verify the presence of the water masses in the positions indicated. Measurements of water temperature and conductivity of the water were used as verification tests because influent waters from the St. Clair River, Chenal Ecarte, the Clinton River, and The Clinton River Spillway differed from each other in these parameters. In the verification process the NAIAD, furnished with photographs of the model's outflows of the St. Clair, Clinton, and Chenal Ecarte-Johnston Channel, went to the indicated positions of the outflows in the lake and tested for the typical temperatures and conductivities. In all cases the vessel found that the outflows of the waterways were present in the positions indicated by the model.

The currents recorded by the current indicator at the Beach were also used in checking the alongshore currents of the model. Agreement was satisfactory, but the current indicator could sense small scale current variations that could not be seen in the model.

The predominant current directions recorded by the current indicator agreed well with the alongshore currents in the model.

In connection with the local sediments and the alongshore (littoral) transport of sediments by the currents, use was made of surveys on foot, studies of the bottom topography as revealed by U. S. Lake Survey Charts, and the tracing of labelled local sands.

Littoral transport of sediment was of particular importance in connection with the channel of the proposed West Boat Lagoon. To investigate the possibility of filling-in of this channel, sand was collected in two-bushel lots from the most inshore sand bar just to the east of the proposed channel. These sand samples were dried and covered with a very thin solution of a paint that fluoresces brilliantly under ultra-violet light. When dry, this painted sand was reintroduced into the same hole (in the sand bar) from which it was taken. To ascertain the movements of the sand, the areas to both east and west of the sand planting were sampled in a grid pattern of samples at 50-foot intervals along lines bearing 185° magnetic. Lines of samples were spaced at 150-foot intervals to east and west of the central line across the sand-plant site. Plants of blue sand (on 31 July 1962) and red sand (on 18 October 1962) were made. The area was grid-sampled on 7 August 1962, 31 August 1962, 14 November 1962, and 15 August 1963. Colored sand grains in aliquots of the samples were counted under ultraviolet light.

Water-mass identification by water temperature and by conductivity of the water was mentioned earlier in connection with verification of the model. In view of the obviously poor water

quality of the Clinton River and Black Creek, it was also deemed advisable to include the determination of total residue upon evaporation and filterable solids (solids recovered by evaporation of filtered water). Samples for conductivities and residues were collected from the St. Clair River, open Lake St. Clair, the Clinton River above its mouth, Black Creek at its mouth and above its mouth, and along shore at the west end of the Beach bathing area.

The results of the Beach's bacteriological water-quality samplings were also studied to see if there was correlation with currents and/or wind direction.

Since there is little if any information available on the chemistry of Lake St. Clair water, one set of samples from the west end of the bathing area was analysed for total phosphorus, Kjeldahl nitrogen, and nitrate nitrogen.

RESULTS AND DISCUSSION

The opening of the Southeast Bend Cutoff Channel, in the South Channel of the St. Clair River, in the spring of 1962 was followed by unusually good bacteriological water quality at the Beach. In order to ascertain whether the improved water quality at the Beach was a result of 1) the Cutoff Channel, 2) an unusual prevalence of southeast winds, 3) a combination of the two, or 4) neither, it was necessary to find the best possible indication of the long-term local winds.

The Long-Term Wind Regime

Some ten miles northwest of Metropolitan Beach is Selfridge Air Force Base. This installation records hourly weather observations and is the nearest source of high-quality weather data. A long series (December 1936 to January 1953) of hourly wind data from Selfridge have been reduced to percentage occurrence of winds from the various directions by personnel of the Base.

Detailed comparisons and correlations were made between simultaneous winds at the Beach and at Selfridge during the months of July through October 1962. A very high degree of correlation was obtained. It is evident that there is no essential difference between the winds at the two places; the long-term monthly mean winds at Selfridge can thus be used for those at the Beach. The long-term monthly wind frequencies at Selfridge are given in Figure 1. In the wind roses the winds blow toward the center. During the months of June through October the most frequent winds are from the south and southwest;

WIND FREQUENCY ROSES - MONTHLY NORMS

(BASED ON SELFDRIDGE AFB REPORTS DECEMBER 1936 - JANUARY 1953)
ROSES FOR WINDS ≥ 4 MPH

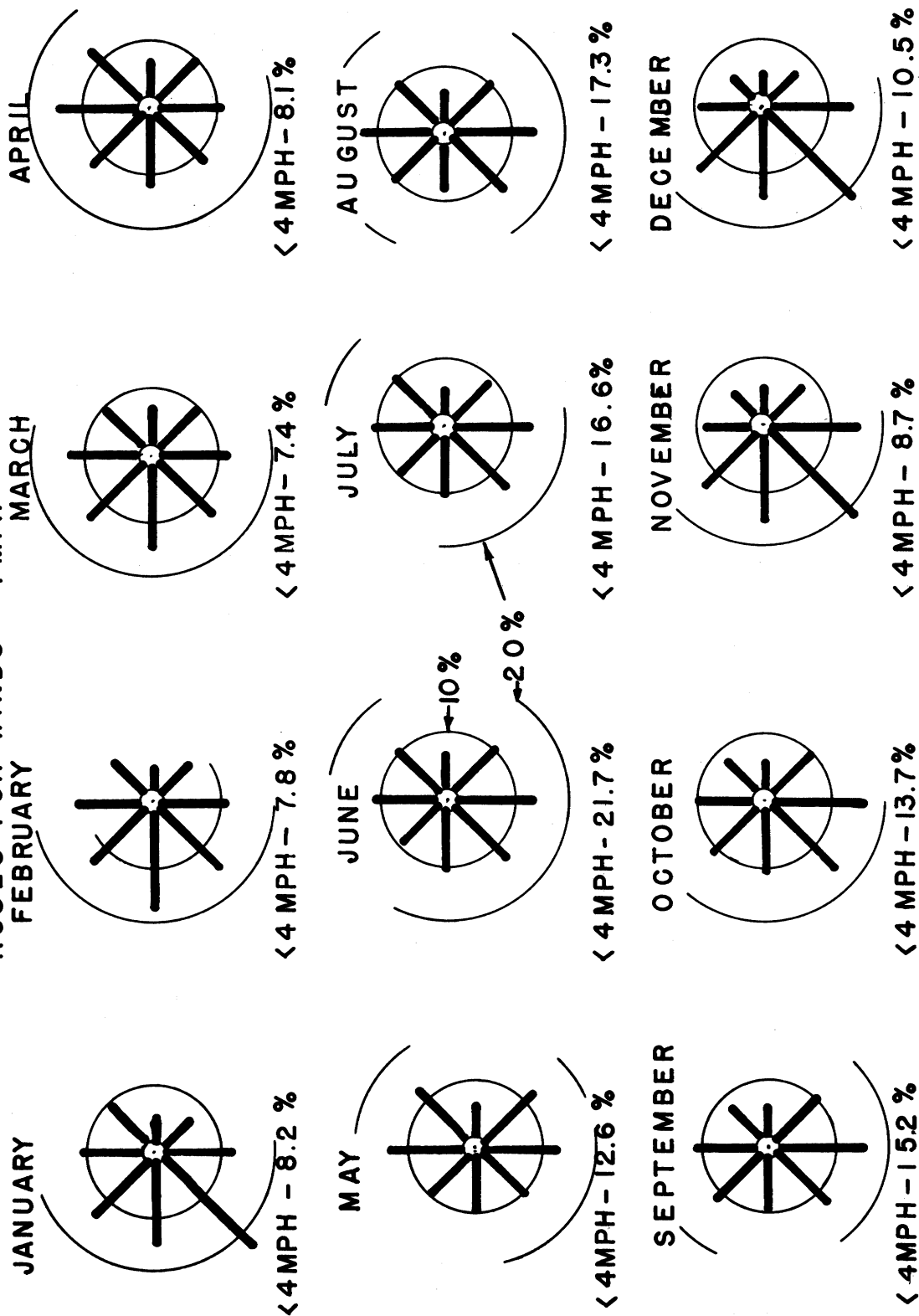


Fig. 1

winds from the southwest to northwest are most frequent from November through March; and winds from the north and northeast are the most frequent in April and May, though May has frequent winds from south and southeast.

Observed Winds, 1962, 1963

In Figure 2 are presented the wind frequencies observed at the Beach during August through October 1962 and June through August 1963. Data for these months are presented because these are the months when bathers frequent the Beach and, consequently, when problems of weeds, other flotsam, and water quality are of most interest.

Comparison of August 1962 to August 1963 in Figure 2 illustrates the variability of the wind from year to year. Comparison of the two Augusts to the long-term August winds of Figure 1 shows that neither of the observed Augusts may be considered "typical."

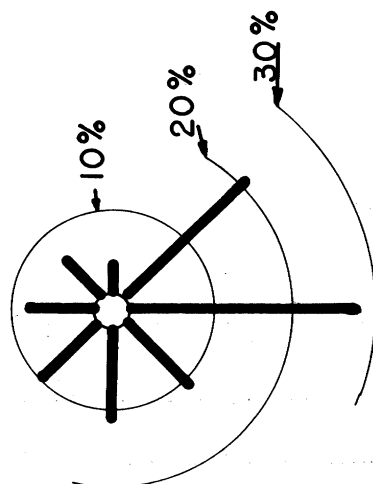
Similarly, June 1963, July 1963, September 1962, and October 1962 are also "atypical" in that their winds were different from the long-term norms.

August 1962 was a month with an exceptional frequency of winds from the southeast. August 1963 had unusually frequent winds from the west and northwest.

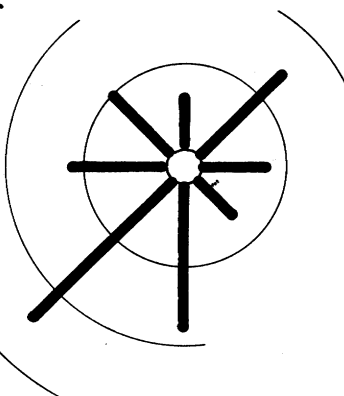
June 1963 had unusually abundant winds from the northwest and southeast, while July 1963 had unusually frequent winds from the northwest, north, and southeast. September 1962 had more winds than usual from the northwest, west, and southeast. October 1962 had unusually-common winds from the west and northwest.

WIND FREQUENCY ROSES METROPOLITAN BEACH (BASED ON HOURLY OBSERVATIONS)

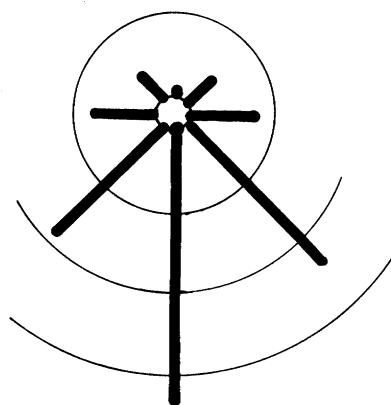
AUGUST, 1962



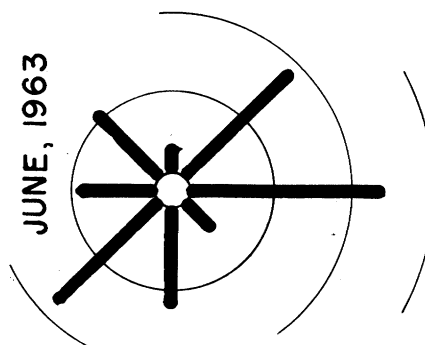
SEPTEMBER, 1962



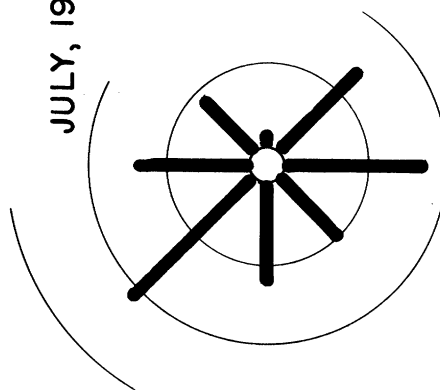
OCTOBER, 1962



JUNE, 1963



JULY, 1963



AUGUST, 1963

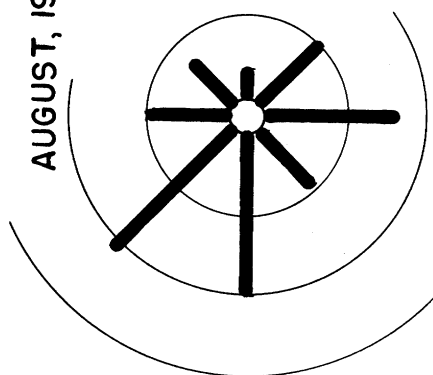


Fig. 2

Observed Alongshore Currents

In October 1962 drogues were used to check the validity of alongshore currents being recorded by the current indicator installed at the west end of the bathing beach. These runs, plus visual observations of current direction at about weekly intervals when the recording station was serviced, showed that the current indicator was correctly indicating current direction.

The drogue studies also showed that the alongshore current moves in a wide belt, and that along the Beach property there were no local eddies. On the basis of these studies it was determined that dominant currents recorded by the current indicator could be used in verification of the models.

Alongshore Currents in Relation to Wind

In Figure 3 are presented the directions of alongshore currents recorded under the eight wind directions. The wind (direction from) is indicated above each current frequency rose. Arrow-heads on the rays of the roses indicate that currents are named by the direction toward which they move.

Velocity of alongshore currents is less important than current direction in the particular practical problems underlying this study. In general the stronger of the alongshore currents were the most consistent of the currents; weaker currents involved greater percentages of "calms" when no current was recorded. Calms are a function of sheltering by the land while current velocities are, at least in part, a function of the length of open water across which the wind blows. Table 1 gives the observed percentages of calms (no discernable current) in the alongshore water as recorded by the current indicator.

FREQUENCY OF ALONGSHORE CURRENT DIRECTIONS
UNDER EACH WIND DIRECTION
(BASED ON HOURLY OBSERVATIONS)

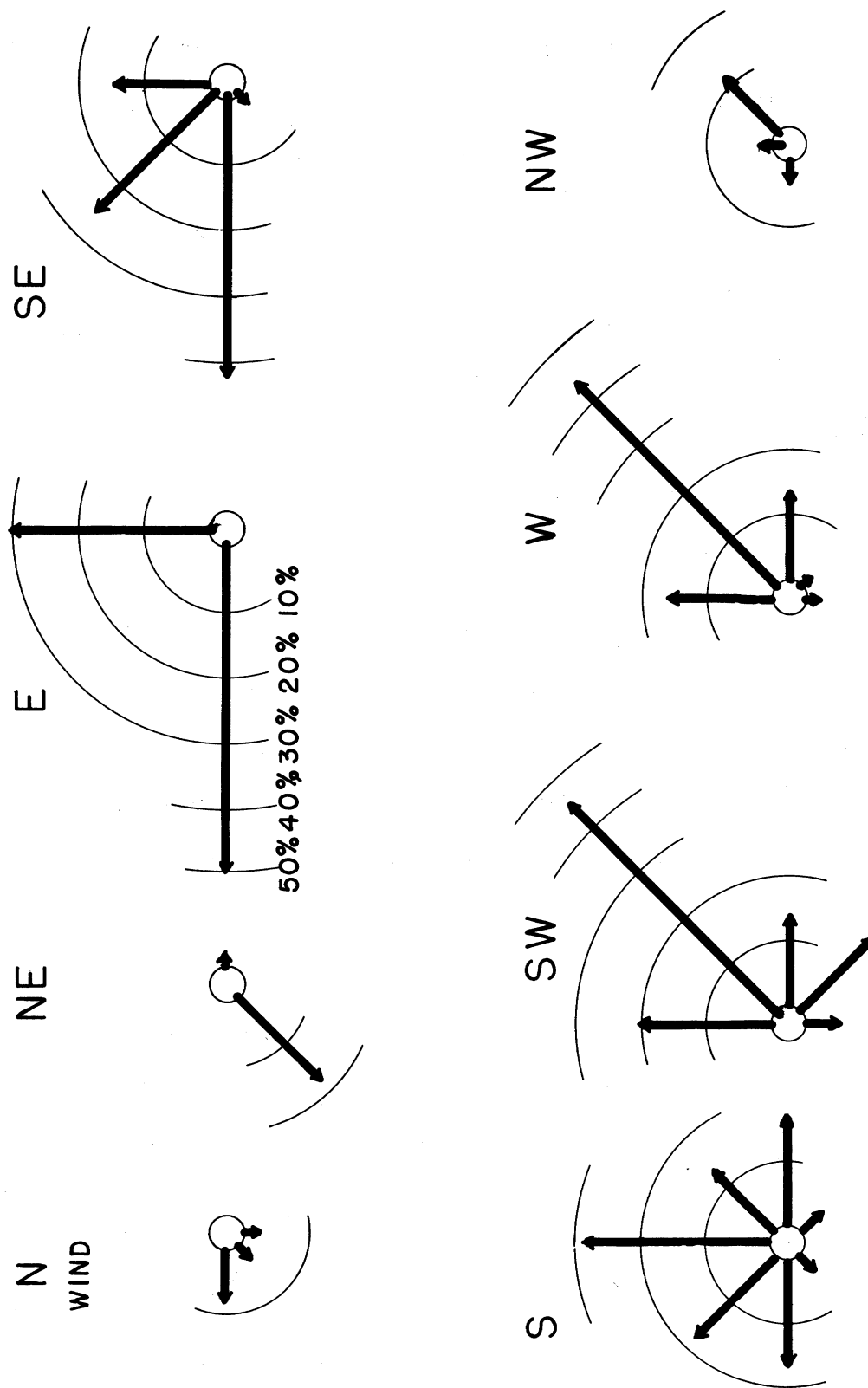


Fig. 3

Table 1. Percentage of Current Calms Observed
Under the Eight Wind Directions

<u>Wind from</u>	<u>% of Calms</u>
N	ca 87%
NE	ca 76%
E	ca 20%
SE	ca 18%
S	ca zero
SW	ca 1%
W	ca 22%
NW	ca 83%

Under winds from northwest around through northeast the alongshore water is sheltered by Huron Point, and these winds produced few and generally weak alongshore currents.

Winds from the southeast through south and southwest almost always produced alongshore current. Winds from east and west produced current only slightly less often.

Modelled Lake St. Clair Currents

The original impetus to the modelling of Lake St. Clair was the need to ascertain whether the opening of the Southeast Bend Cutoff Channel in spring of 1962 made a major contribution to the good water-quality at Metropolitan Beach in the summer of 1962.

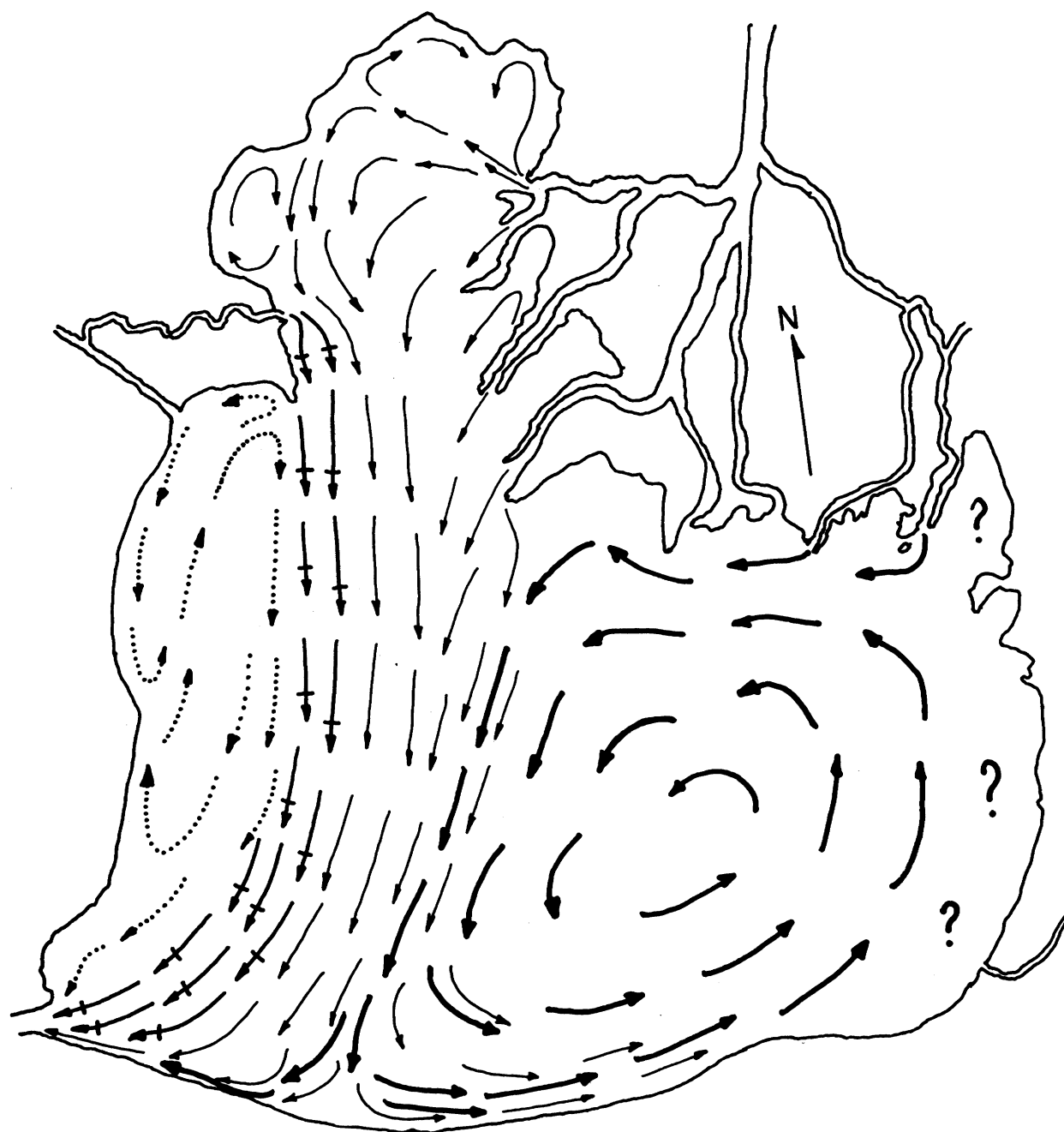
It was reasoned that a lake model containing the Cutoff Channel could be verified against present conditions in the lake, and then the Cutoff Channel in the model could be closed. The model then might be expected to provide a reasonable indication of conditions prior to the opening of the Cutoff. The model was operated in this manner.

The synthesized results of multiple runs under each of the eight winds are presented in Figures 4 through 19.

Figs. 4 through 19. Modelled currents of Lake St. Clair.

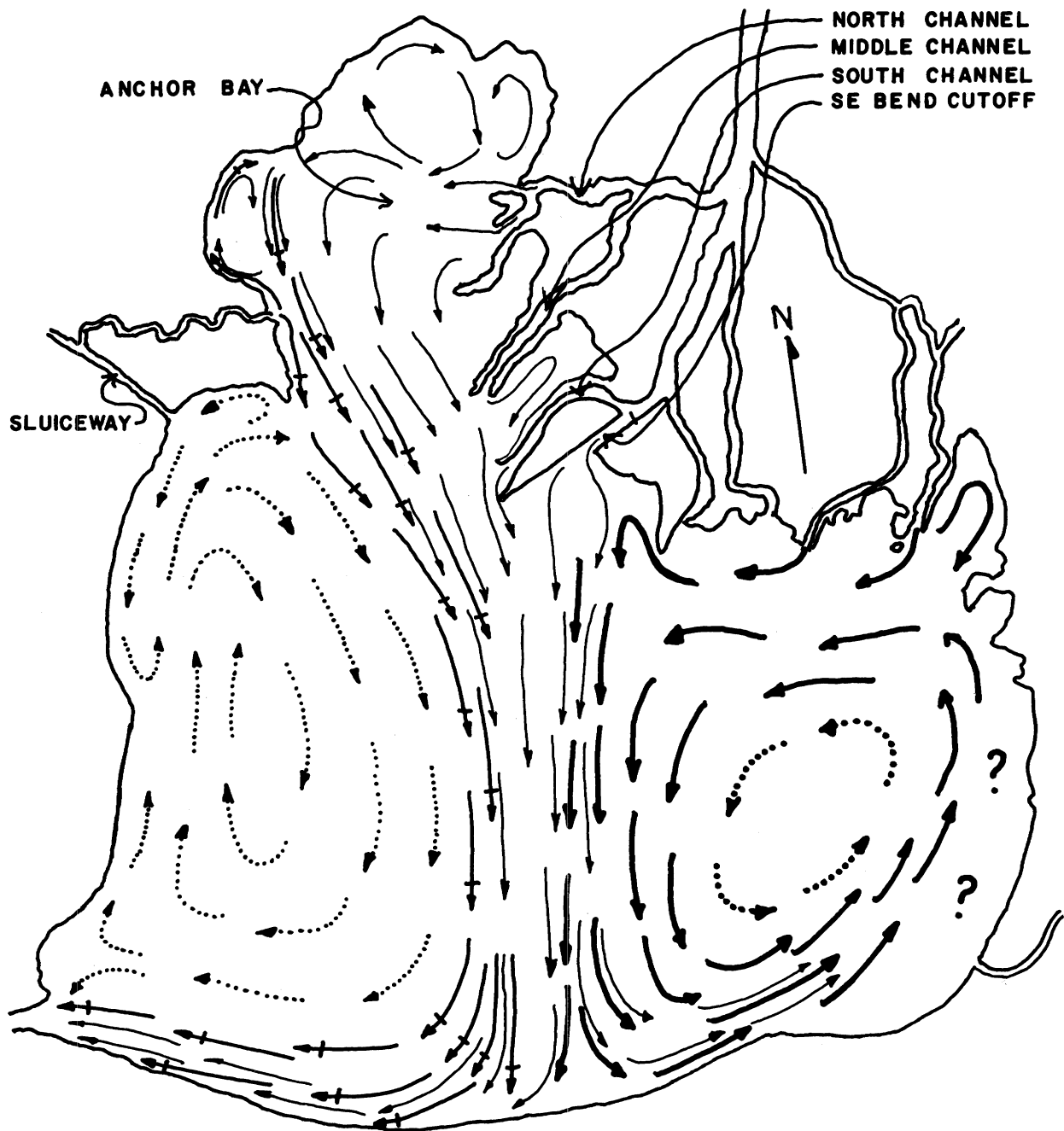
In these figures the current arrows denote direction only.

The outflows of Chenal Ecarte-Johnston Channel, the St. Clair River, and the Clinton River are denoted by arrows of different widths. "Water left by previous wind" means a discrete mass of water not relatable to any of the above sources but which partook in the lake's circulation as indicated. Place-names used in this section are shown on Figure 5.



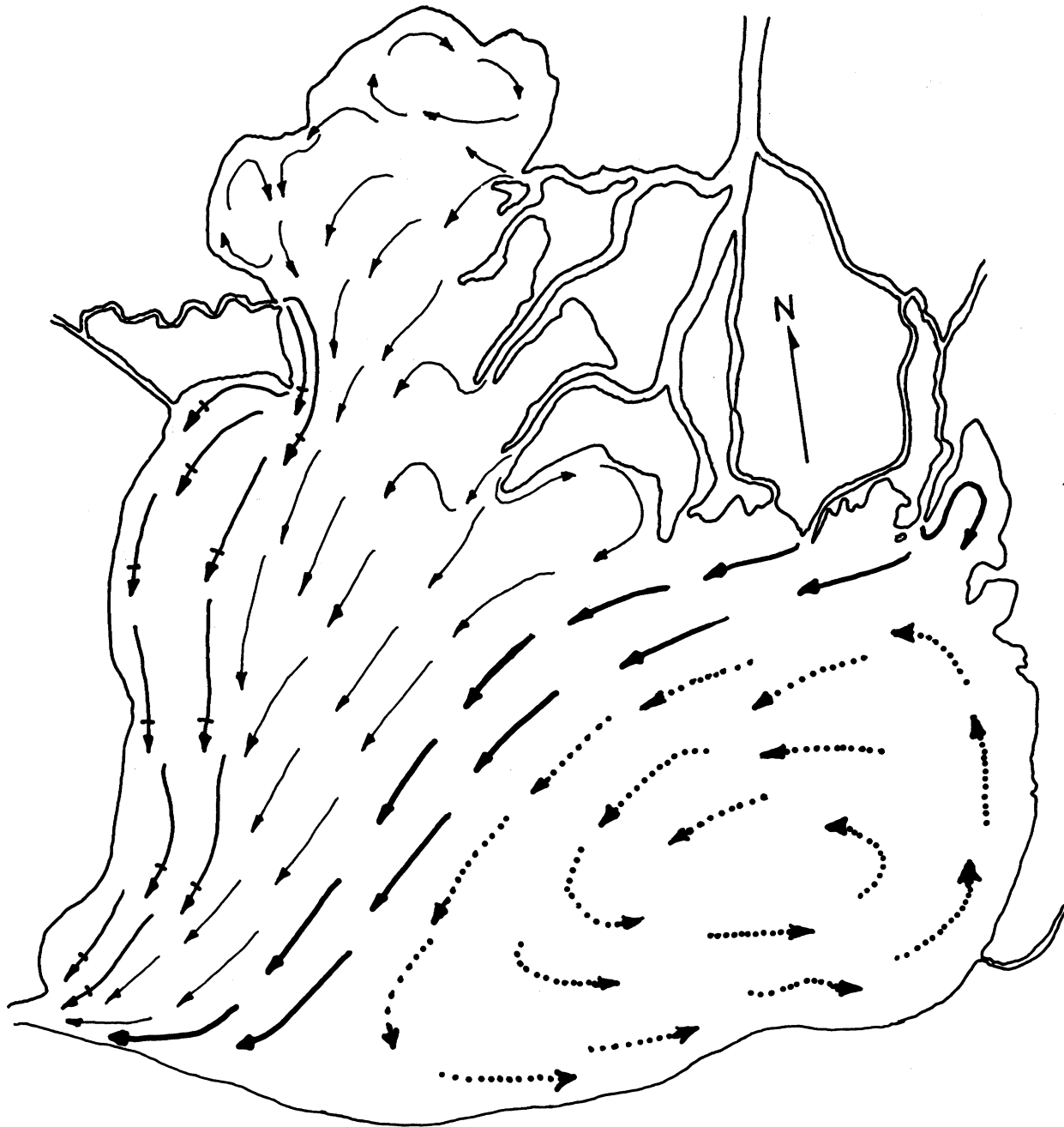
—————> = CHENAL ECARTE & JOHNSTON CHANNEL
 —————> = ST. CLAIR RIVER
 ———+———> = CLINTON RIVER
> = WATER LEFT BY PREVIOUS WIND
 NORTH WIND
 PRE-CUTOFF

Fig. 4



- > = CHENAL ECARTE & JOHNSTON CHANNEL
 —————> = ST. CLAIR RIVER
 ———+———> = CLINTON RIVER
> = WATER LEFT BY PREVIOUS WIND
- NORTH WIND**
POST-CUTOFF

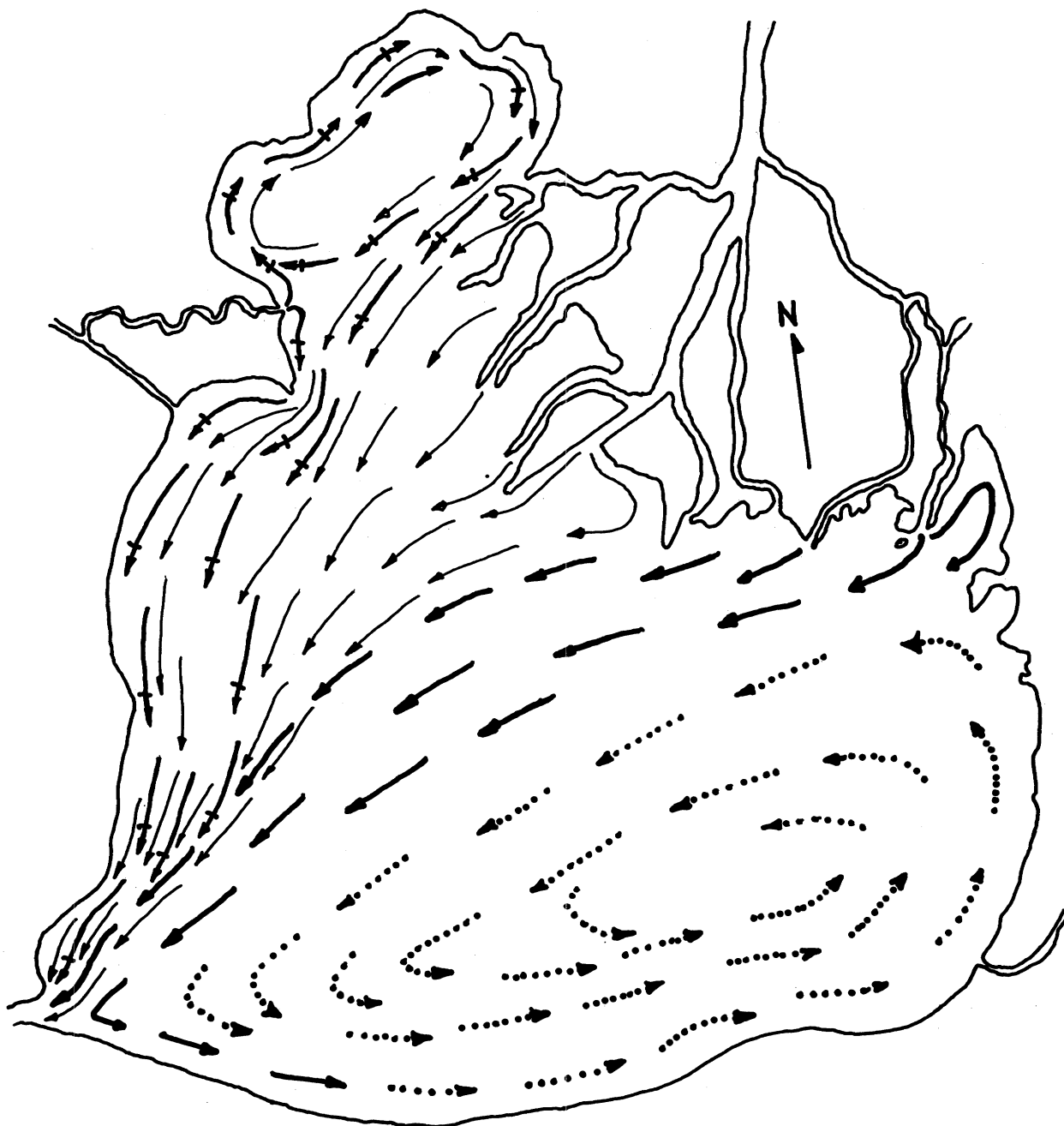
Fig. 5



- > = CHENAL ECARTE & JOHNSTON CHANNEL
- > = ST. CLAIR RIVER
- +> = CLINTON RIVER
-> = WATER LEFT BY PREVIOUS WIND

**NORTHEAST WIND
PRE-CUTOFF**

Fig. 6



- > = CHENAL ECARTE & JOHNSTON CHANNEL
- > = ST. CLAIR RIVER
- +> = CLINTON RIVER
-> = WATER LEFT BY PREVIOUS WIND

**NORTHEAST WIND
POST-CUTOFF**

Fig. 7



- > = CHENAL ECARTE & JOHNSTON CHANNEL
- > = ST. CLAIR RIVER
- +> = CLINTON RIVER
-> = WATER LEFT BY PREVIOUS WIND

**EAST WIND
PRE-CUTOFF**

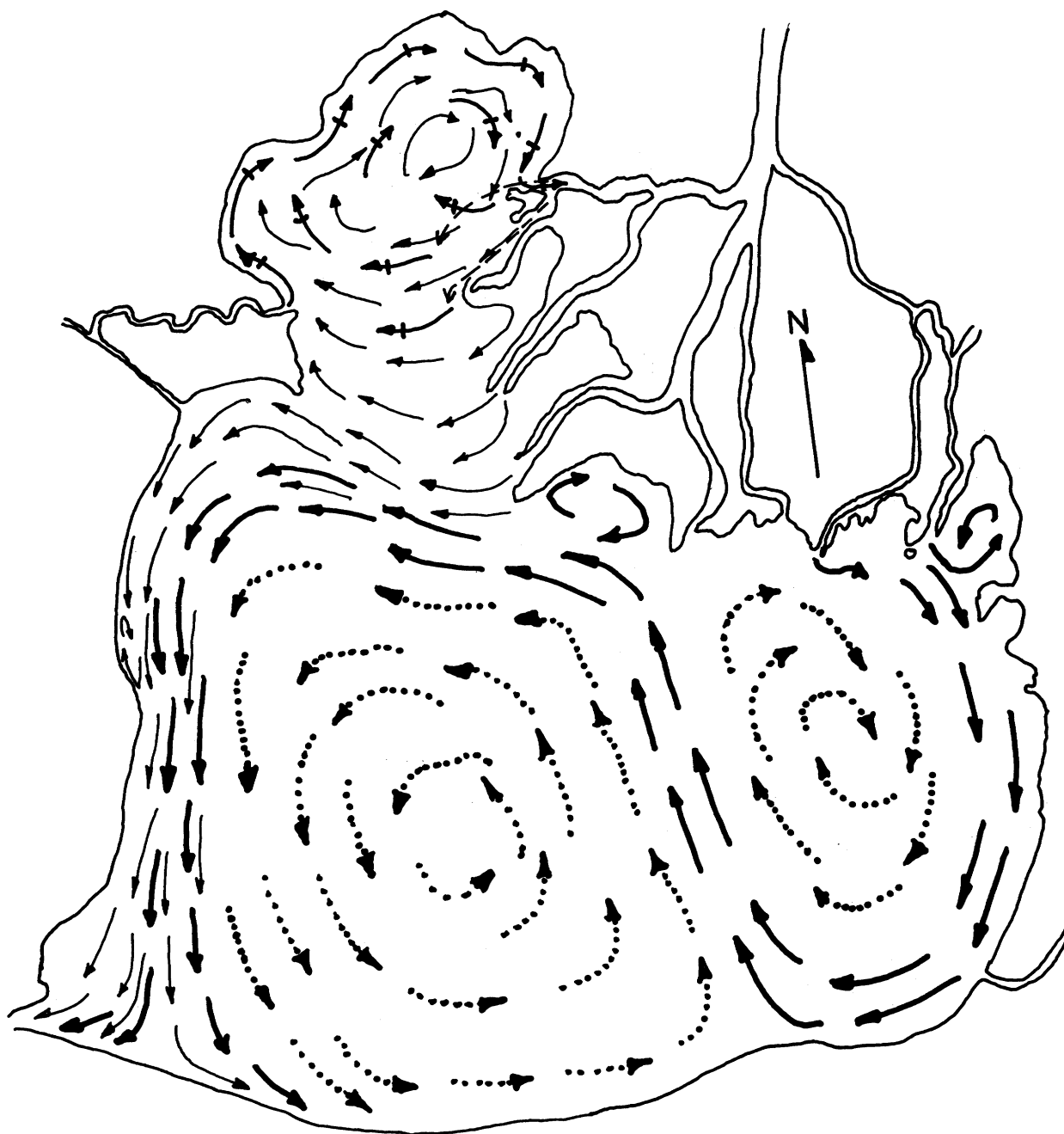
Fig. 8



- > = CHENAL ECARTE & JOHNSTON CHANNEL
- > = ST. CLAIR RIVER
- +> = CLINTON RIVER
-> = WATER LEFT BY PREVIOUS WIND

**EAST WIND
POST-CUTOFF**

Fig. 9



- > = CHENAL ECARTE & JOHNSTON CHANNEL
- > = ST. CLAIR RIVER
- +> = CLINTON RIVER
-> = WATER LEFT BY PREVIOUS WIND
- > = SUBSURFACE OUTFLOW

SOUTHEAST WIND
PRE-CUTOFF

Fig. 10



- > = CHENAL ECARTE & JOHNSTON CHANNEL
- > = ST. CLAIR RIVER
- +> = CLINTON RIVER
-> = WATER LEFT BY PREVIOUS WIND
- > = SUBSURFACE OUTFLOW

SOUTHEAST WIND
POST-CUTOFF

Fig. 11



- > = CHENAL ECARTE & JOHNSTON CHANNEL
 - > = ST. CLAIR RIVER
 - +> = CLINTON RIVER
 -> = WATER LEFT BY PREVIOUS WIND
- SOUTH WIND
PRE-CUTOFF**

Fig. 12



—————> = CHENAL ECARTE & JOHNSTON CHANNEL
 —————> = ST. CLAIR RIVER
 ———+———> = CLINTON RIVER
> = WATER LEFT BY PREVIOUS WIND
 SOUTH WIND
 POST-CUTOFF

Fig. 13



- > = CHENAL ECARTE & JOHNSTON CHANNEL
- > = ST. CLAIR RIVER
- +———> = CLINTON RIVER
-> = WATER LEFT BY PREVIOUS WIND
- > = SUBSURFACE ESCAPEMENT

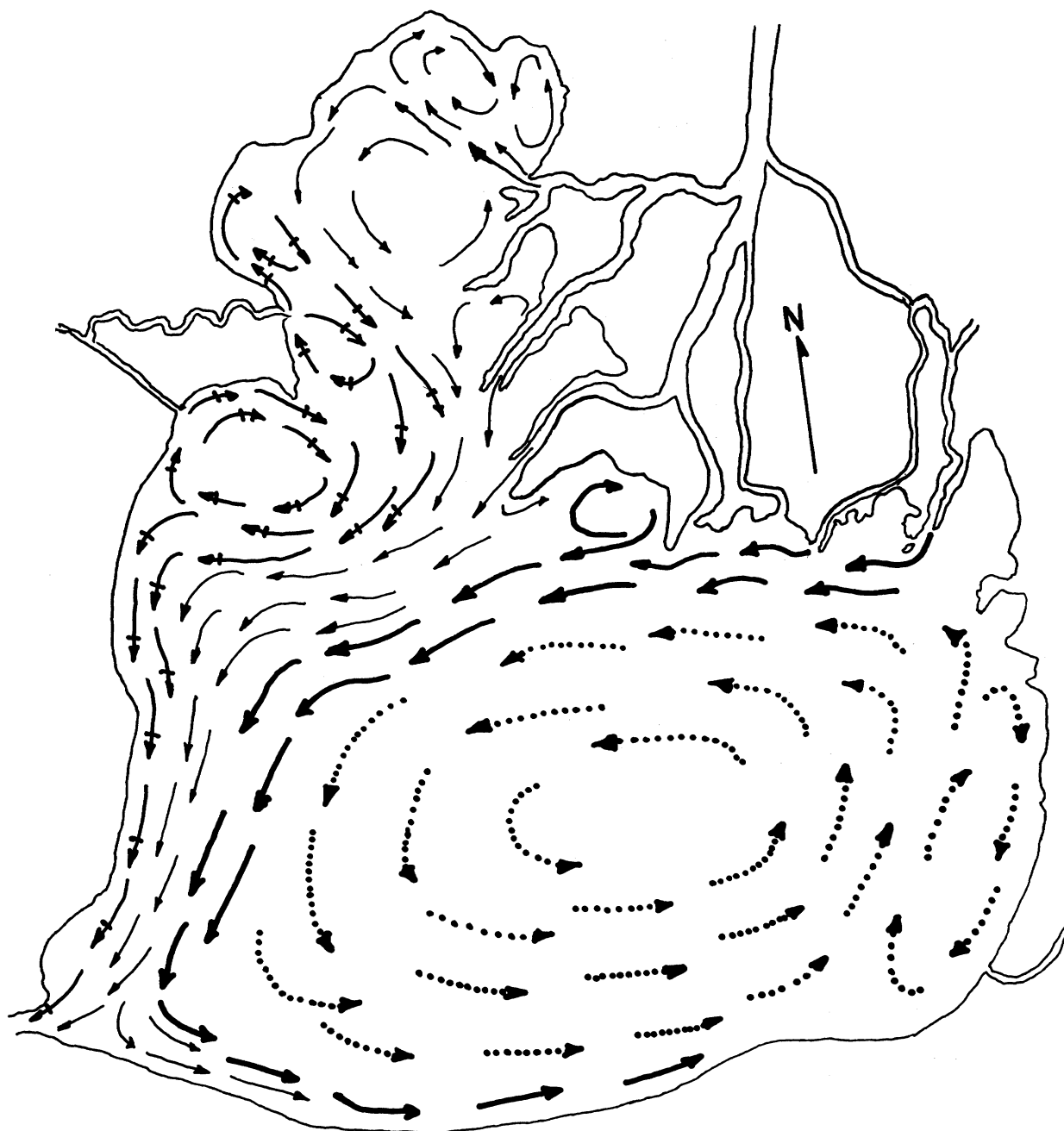
**SOUTHWEST WIND
PRE-CUTOFF**

Fig. 14



- > = CHENAL ECARTE & JOHNSTON CHANNEL
 - > = ST. CLAIR RIVER
 - +> = CLINTON RIVER
 -> = WATER LEFT BY PREVIOUS WIND
 - > = SUBSURFACE ESCAPEMENT
- SOUTHWEST WIND
POST-CUTOFF**

Fig. 15



- > = CHENAL ECARTE & JOHNSTON CHANNEL
- > = ST. CLAIR RIVER
- +> = CLINTON RIVER
-> = WATER LEFT BY PREVIOUS WIND

WEST WIND
PRE-CUTOFF

Fig. 16



- > = CHENAL ECARTE & JOHNSTON CHANNEL
- > = ST. CLAIR RIVER
- +> = CLINTON RIVER
-> = WATER LEFT BY PREVIOUS WIND
- > = SUBSURFACE OUTFLOW & ESCAPEMENT

WEST WIND
POST-CUTOFF

Fig. 17



- > = CHENAL ECARTE & JOHNSTON CHANNEL
- > = ST. CLAIR RIVER
- +> = CLINTON RIVER
-> = WATER LEFT BY PREVIOUS WIND

**NORTHWEST WIND
PRE-CUTOFF**

Fig. 18



- > = CHENAL ECARTE & JOHNSTON CHANNEL
 —————> = ST. CLAIR RIVER
 —————> = CLINTON RIVER
> = WATER LEFT BY PREVIOUS WIND

**NORTHWEST WIND
POST-CUTOFF**

Fig. 19

Effect of Opening the Cutoff: It is difficult to generalize about the effects of the opening of the Southeast Bend Cutoff Channel. The greater cross-sectional area for outflow which now exists and the straightening that the new channel provides should decrease frictional effects and promote a greater discharge of St. Clair River water directly into the main lake basin. It appears, however, that winds blowing along the four channels are still generally regulating the distribution of the St. Clair River outflow.

Visible effects of the delivery of increased volume of St. Clair River water to the main lake basin are present under winds from the north, southeast and west. These are believed to be direct effects of wind stress.

North winds blowing down the St. Clair River are aided by the Cutoff Channel in driving river water more directly into the main basin. The river discharge under this wind has shifted eastward with the opening of the Cutoff.

Southeast winds appear to have added the outflow of the Cutoff canal as a belt along the south side of the flows from North, Middle and South Channels, while the surface of North Channel flows upstream as a result of set-up in Anchor Bay.

West winds blow almost directly upstream in North Channel; they also cause set-up of Anchor Bay water on the east side of the Bay. North Channel now reverses its surface flow and adds water to the main channel of the river, which in turn apparently discharges the increase through the Cutoff Channel which is somewhat sheltered from this wind.

The opening of the Cutoff Channel has apparently made little

change in the circulation of the main basin under winds from the northeast, east, southwest, and northwest.

Northeast winds blow downstream along Middle Channel, South Channel, and the Cutoff. From the current pattern in the lake's main basin alone it would appear that the Cutoff Channel was only dividing the outflow that previously would all have emerged through South Channel, but the fact that the Clinton River discharge now enters Anchor Bay would argue for some reduction of outflow through North Channel.

East winds blow downstream along North Channel and along an inner part of South Channel, with wind pressure augmenting outflow in both. The Cutoff Channel, again, appears to only divide into two parts what would have originally been the outflow of South Channel.

Southwest wind puts a back-pressure onto the surfaces of the Cutoff, South Channel, and Middle Channel. The opening of the Cutoff appears to have provided some critical addition of cross-sectional area for flow into the main basin, for North Channel now reverses at least its surface flow (under pressure of this wind on the surface of Anchor Bay) where previously it did not. The total effect under this wind appears to be a net diminution of outflow through North Channel with diversion of the flow difference to the (probably) subsurface levels of the Cutoff Channel.

Northwest winds blow diagonally across the mouths of North, Middle, South, and the Cutoff Channels. Again, the Cutoff Channel appears only to divide the original South Channel flow.

The opening of the Cutoff Channel allows the south wind to put a more effective back-pressure onto the lower reach of the

St. Clair River with more reduction of outflow than was possible when the undivided island offered some shelter to South Channel. This reduction of hydraulic pressure from the two lower channels appears to allow the northward cross-lake current to come further up along the west side of the delta than previously. The back-pressure on the lower reach of the River apparently increases the outflow of North Channel, with increased complexity of the circulation in Anchor Bay.

The outflow of the Clinton River now enters, at least in part, into Anchor Bay under all winds. The model indicated that, prior to the Cutoff Channel, Clinton River water did not enter Anchor Bay under winds from the north, northeast, or south, and that only a small amount entered under west winds. Reduced outflow through North Channel since the Cutoff under winds from the north, northeast, and west has been deduced above. Under south wind the Cutoff Channel appears to increase the effective upstream wind-pressure in the lower reach of the St. Clair River and to thus allow the main cross-lake current to come to the mouth of Anchor Bay; the Clinton River outflow appears to be drawn in part into Anchor Bay by a portion of the cross-lake current that enters the Bay.

It appears possible that the increased admixture of Clinton River water into Anchor Bay may be resulting in somewhat poorer water quality in the Bay.

The increased dilution of Clinton River water with North Channel water in Anchor Bay before entry into the main basin might be expected to result in somewhat better water quality in the main lake basin.

The degree of water-quality changes to be expected in Anchor

Bay and in the main lake basin could not be told from the model. The model did, however, consistently indicate that waters along the lake's western shore now contain a higher proportion of St. Clair River water than was the case prior to opening of the Cut-off Channel. Whether or not the possible improvement in water quality that this would imply can be detected over the local additions of poor-quality water along the west shore is not known.

Modelled Beach Currents

Flotsam Deflection: The action of alongshore currents at Metropolitan Beach was studied in a larger-scale model of the immediate area. The purpose of these studies was two-fold: 1) to ascertain whether weeds and other flotsam could be deflected past the Beach bathing area under southwest winds, and 2) to study the action of alongshore currents on the littoral transport of sand.

Figure 20 shows a system of two deflectors that was capable of forcing flotsam to by-pass the Beach bathing area under southwest wind. The pair of deflectors included a long one that protected the bathing area and a short one on the east side of the tip of Huron Point. The latter deflector was necessary to prevent flotsam from working around the end of the long deflector.

The main deflector was 6000 scaled feet long. It ran from the beach at a point just west of the West Umbrella Stand generally southeastward to a point 1250 scaled feet beyond the tip of Huron Point on the centerline of the point. The small deflector was 1000 scaled feet long. It began at a point 250 scaled



Fig. 20. Flotsam deflectors in place in the model.



Fig. 21. Deflectors forcing floating dye to by-pass bathing area under southwest wind.

feet north of the tip of the point and continued the line of the east side of the point for about 750 scaled feet beyond the tip of the point.

Figure 21 shows the deflector system deflecting floating dye completely past the bathing area under southwest wind.

It appears from these studies and from the experiences of others that a "floating fence" such as the Warne Inflatable Oil Spillage Boom (which is now being handled in this country by Surface Separator Systems Inc., 103 Mellor Avenue, Baltimore, Maryland) would successfully protect the bathing area from weed and flotsam. Brochures and descriptive materials on this "fence" were loaned to Mr. R. M. Klenner.

Littoral Sand Transport

Figures 22, 23, 24, 25, 26 and 27 show the distributions of painted sand grains from plantings of sand on the inshore sand bar just to the east of the channels of the proposed West Boat Lagoon.

The great bulk of the marked sands moved diagonally offshore and westward toward the extensive shoal area off Stella Mare and the western edge of the Metropolitan Beach property.

There was some movement of sand through the cove at the western edge of the Beach property. This movement was in water depths of one to two feet. Very little painted sand was ever found along the present beach of the cove.

The movement of littoral sand seems to be an expression of the southeast winds, which have the greatest open-water distance to blow over, and hence produce the strongest alongshore currents

Figs. 22 through 27. Occurrence of painted sand grains, from plantings at "x", in the area of the West Boat Lagoon. Samplings at "x" and at points indicated by dots.

AUGUST 7, 1962³
 BLUE GRAINS/CM

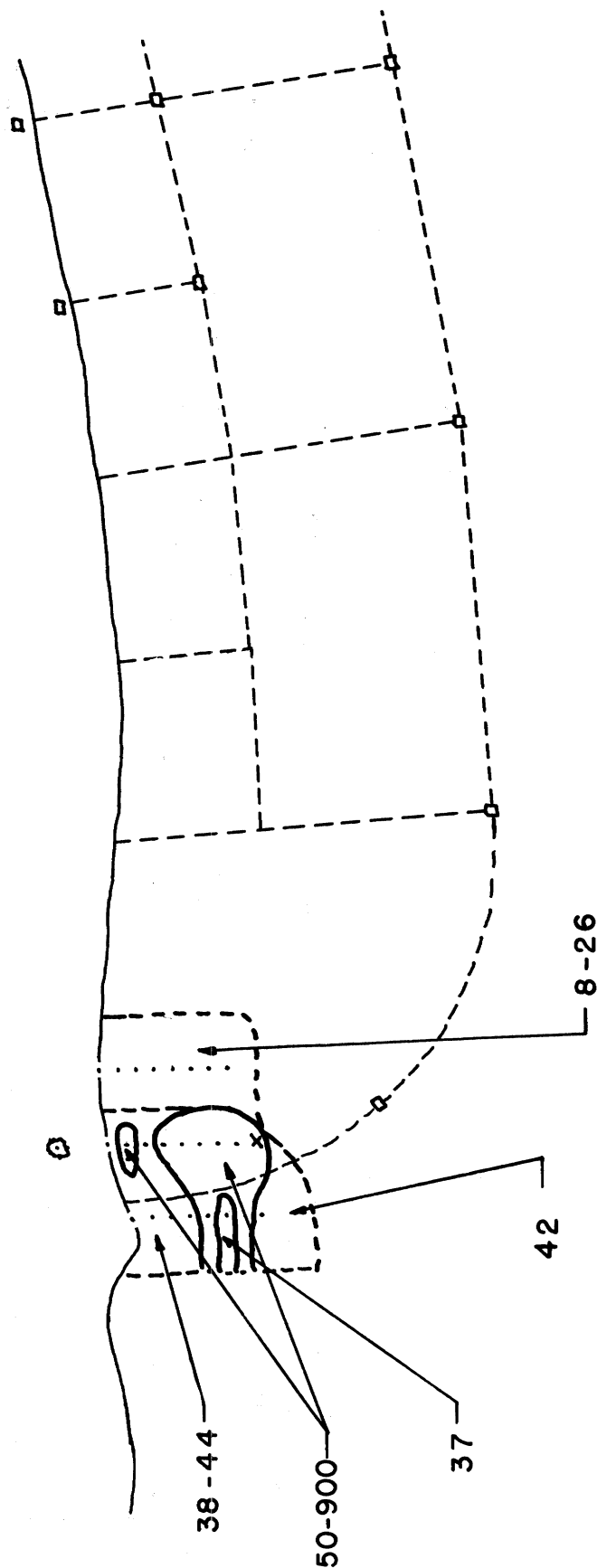


Fig. 22

39

NOVEMBER 14, 1962
BLUE GRAINS/CM³

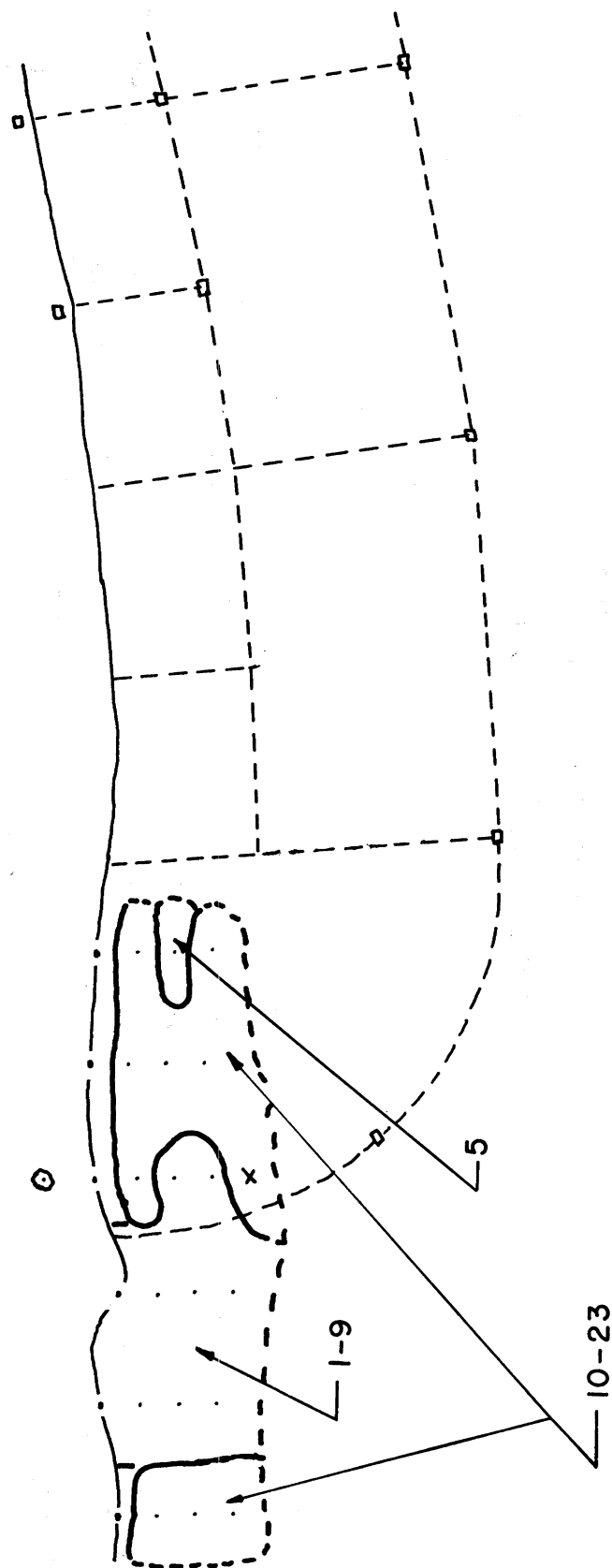


Fig. 24

NOVEMBER 14, 1962
RED GRAINS/CM³

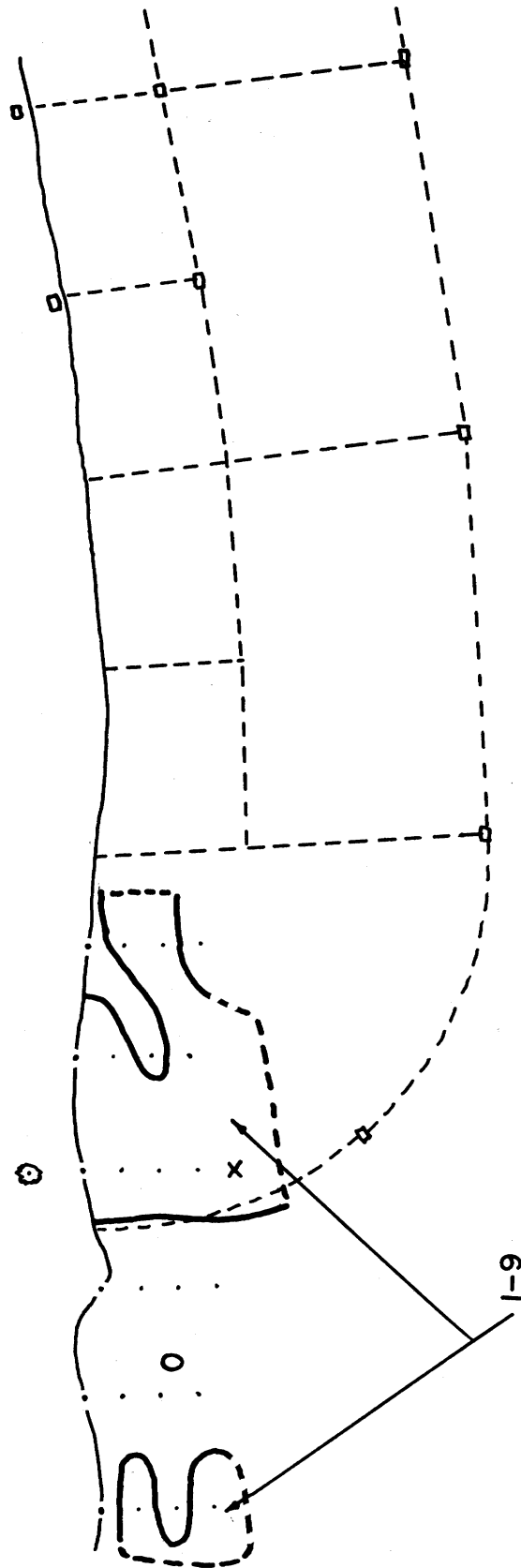


Fig. 25

AUGUST 15, 1963³
RED GRAINS/CM

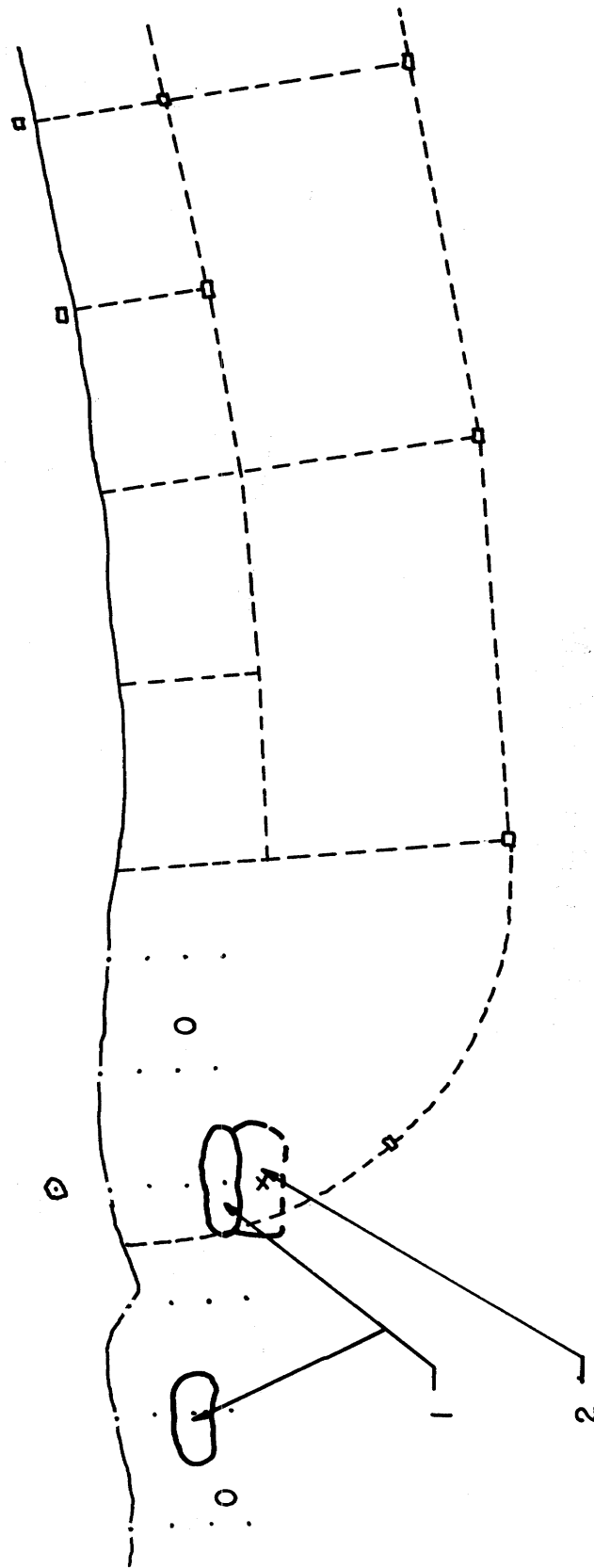


Fig. 26

AUGUST 15, 1963³
BLUE GRAINS/CM

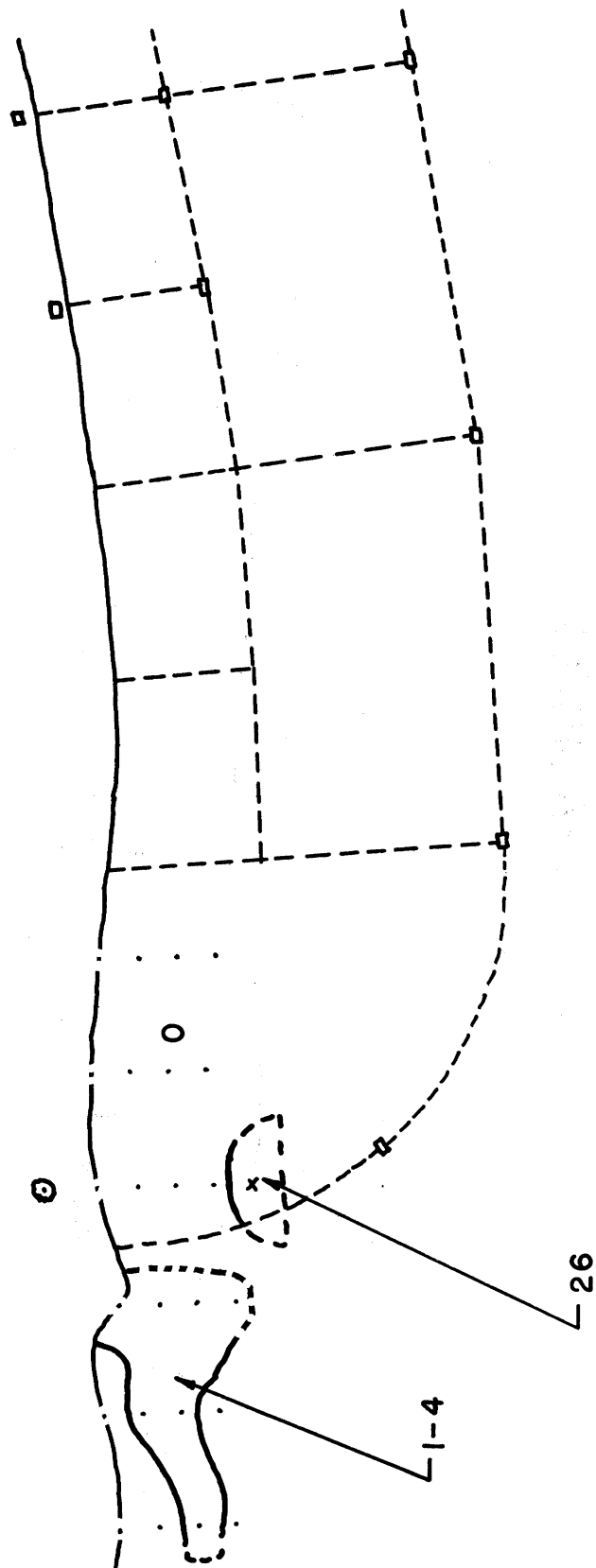


Fig. 27

in the Beach area.

Figure 28 shows the movement of a heavy sinking dye moving along the bottom under the alongshore current of the southeast wind. It, also, moved westward with some dye entering the cove.

Visual inspection of the beach at the proposed channel site shows exposed "marsh bottom" peat layers that are almost devoid of sand cover. The visual inspections suggest that the cove is an area of erosion rather than of deposition.

The evidence indicates that the channels of the proposed West Boat Lagoon would not sand-in where they cross the present beach line.

If dredged channel extension(s) into the lake is (are) planned, there are certain aspects of the hydrography and topography off Metropolitan Beach that bear upon the placement of the channel(s).

Figure 29 presents the pertinent underwater topography, as well as indicative sketches of the Lagoon, the Lagoon exit and entry channels, and the offshore channel, which are discussed below:

The large shoal area, off Cherry Lane, has an extension to eastward (shown by protrusions of the 1-through-5-foot contours) that appear to be built by sediments moving eastward from the Stella Mare shore under prevailing southwest and west winds. The shoal also has a protrusion to the south (shown by the 4-and-5-foot contours).

Between the shoal and the proposed lagoon there are westward protrusions in the 1-through-6-foot contours. These westward protrusions, plus the southward protrusions from the shoal, are

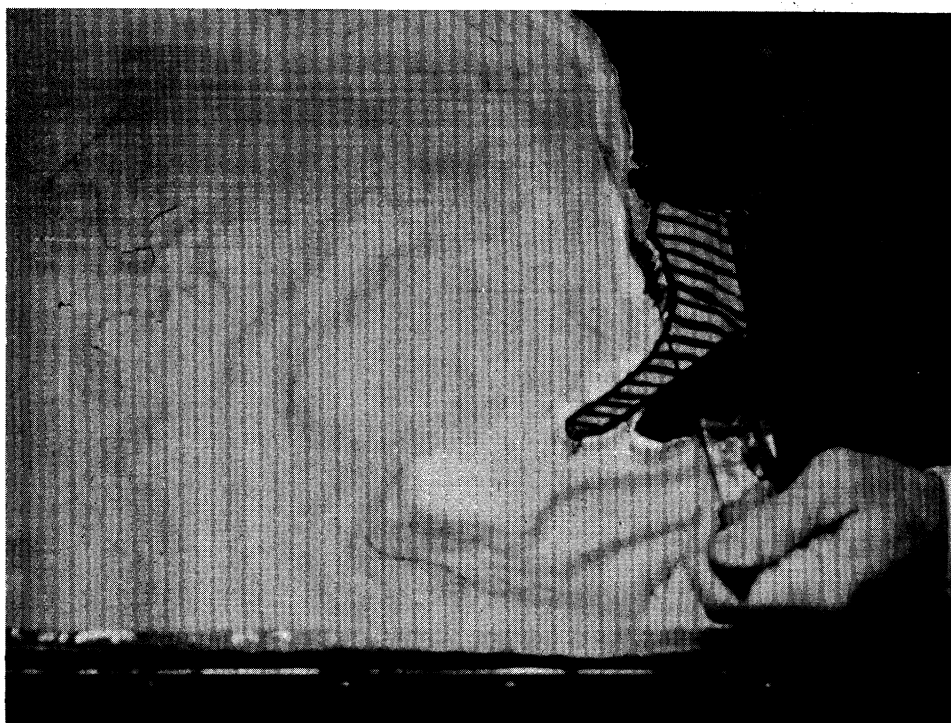


Fig. 28. Sinking dye moving alongshore on the bottom at the cove under southeast wind.

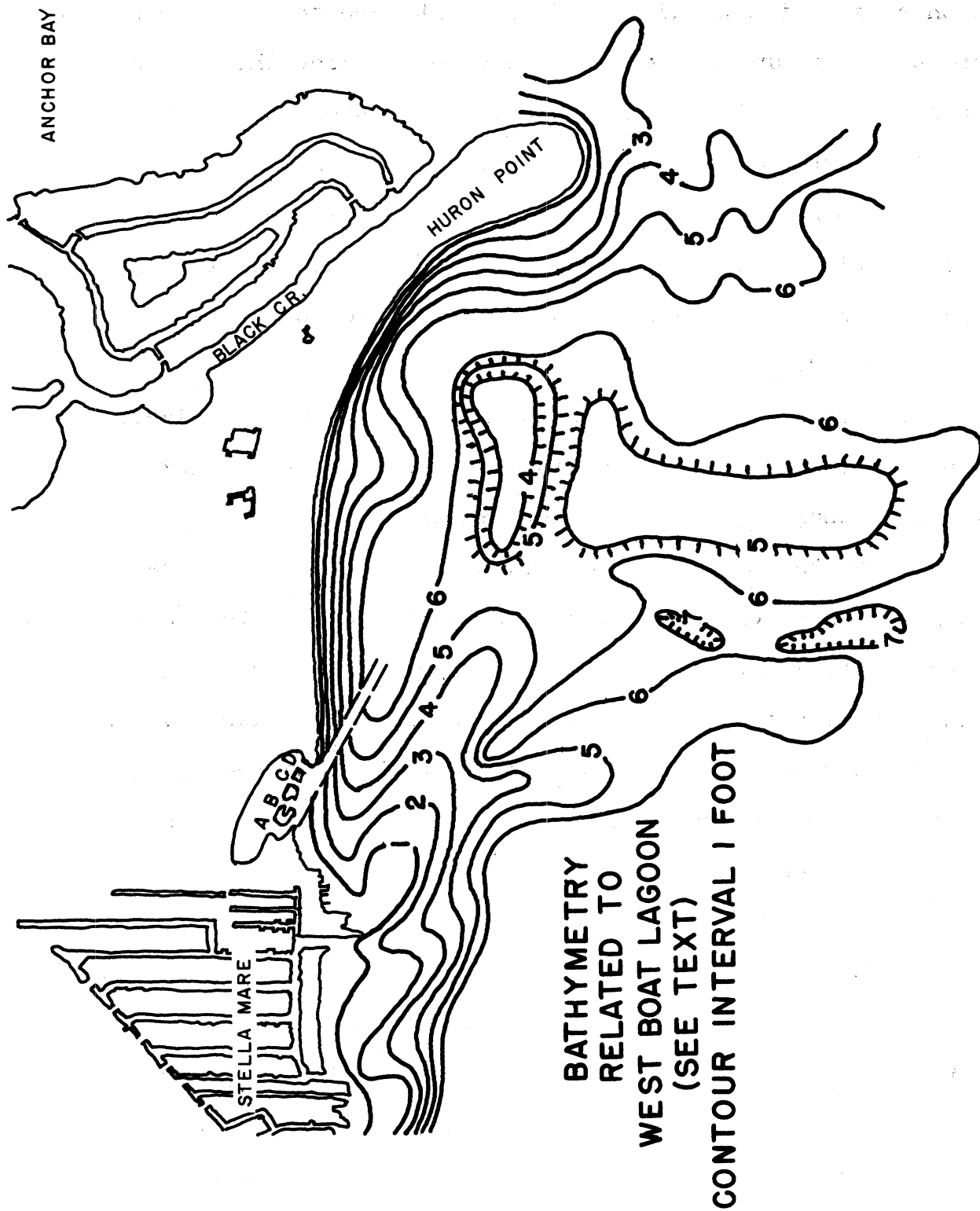


Fig. 29

taken to mean that alongshore currents along the Beach property under southeast winds are eroding the shore of the cove and the north side of the shoal. These currents are then turned southward by the shoreline west of the cove and drop the eroded sediments on the shoal and on its southward extension.

The shape of the shoal indicates the long-period dominance of 1) sedimentation from currents coming from the west and 2) of sedimentation from currents coming from the north. All the evidences discussed earlier in this section are compatible with the conclusions drawn from the underwater topography.

Also from the underwater topography, and also indicating scour under southeast winds, is the success of the Black Creek extension channel, which has not sanded in.

On the basis of all the evidence, it is believed that any dredged channel extending from the beachline into the lake should be angled from the beachline in the same direction as the extension channel off Black Creek. This angle would take advantage of the scour under southeast winds that is indicated by the shapes of the 1-6 foot contours north of the shoal. Figure 29 shows the suggested channel.

To take advantage of channel scour under southeast wind is, however, to have sand moving toward shore in the channel. To avoid this sand being forced into the Lagoon, it is suggested that a 90° angle between the Lagoon's channels and the offshore channel be created to prevent sanding-in of the Lagoon. The Lagoon channels shown on the Master Plan of March 1961 are marked A and B in Figure 29; alternative suggested channels are marked C and D.

If a dredged offshore channel is built as suggested, the channels A and B would be ideally situated to receive the sand that moves inshore in the outer channel. Under these conditions channels A and B would probably develop sand bars at their inner ends where currents entering the Lagoon would loose speed and drop their sand.

To avoid this, it is suggested that channels A and B be replaced by channels C and D situated further east in the Lagoon and oriented northeast-southwest. Further, it is suggested that the initial dredging of the outer channel should include the area in front of old channels A and B, in order that sands moving up the outer channel may fill this area in a natural streamlined manner compatible with the future passage of such sand westward along the unaltered shore of the cove.

The Grey "Ooze"

Samples of the grey "ooze" that forms on the bathing area sand during quiet weather were collected. Also collected were "fines" (silts and clays) that become suspended in lake water in which beach sediment samples had been stirred, and samples of a grey sandy silty clay soil horizon that is exposed in place between sand bars in the bathing area.

These samples were treated with hydrochloric acid in a carbon dioxide production test. The results were as follows:

Grey "clay" of beach soil.....	0.01% CO ₂
"Fines" from sediment samples.....	3.3% CO ₂
"Ooze" sample from beach.....	3.5% CO ₂

It is to be noted that the "fines" obtained from sediment

samples were merely the silt and clay fractions of beach and cove sandy sediment samples. As a first step in preparing these sandy soils for search for painted sand grains, the soils were stirred vigorously with the lake water in which they were transported to Ann Arbor. The supernatant muddy waters were poured off, combined, and allowed to evaporate to dryness in the light and warmth of the laboratory. Exposure to light, heat, and atmospheric gases while in a finely divided state was all that differentiated these fines from the in-place bed clay samples.

Microscopic inspection of the ooze showed mostly an amorphous material resembling fine silt and containing fine organic detritus which may have been of plant origin.

Lime will deposit readily from Lake St. Clair water. The ooze appears to be the silt fraction of the grey sandy silty clay that lies close to the surface in the local soil profile and which is exposed between sand bars in the Beach property. After erosion by alongshore currents the silt apparently acquires both lime and organic detritus from the water. The ooze is harmless but not aesthetic.

Residues Upon Evaporation

The use of conductivity of the water as a means of identifying local water masses has been described previously.

"Conductivity" refers to the ability of the water to transmit an electric current under certain standard conditions. Conductivity increases as the amount of dissolved materials in the water increases. In nearly all cases increase in the amount of dissolved materials in natural water bodies is a measure of the

effects of man, and is accompanied by detrital or non-ionizing materials. In this sense, high conductivity indicates water to which man has contributed, hence water of probably poor quality.

To provide ourselves with data upon the probable qualities of local waters that could reach Metropolitan Beach, and to ascertain their levels of contributed materials, seventeen water samples for comparative conductivity and residue-upon-evaporation determinations were collected in October and November of 1962.

These samples were analyzed for conductivity at uniform temperature (25°C) and corrected back to the 18°C conductivity that was sometimes used in the past.

Half of each sample was then measured and evaporated to dryness, giving the "Total Residue" which was computed in terms of parts per million parts by weight (ppm).

The other half of each sample was passed through a millipore filter (which removed even the bacteria), and evaporated to dryness, giving the "Filterable (filter-passing) Residue" which was also computed in parts per million.

Table 2 presents the results of these analyses, arranged by local water types and generally in the order of decreasing conductivity and residues. It is evident that they are, also, arranged in general order of progressively better water-quality.

This table, unfortunately, does not include one local water type that can reach Metropolitan Beach. That is the water of the Clinton River Sluiceway. This particular water source has a conductivity of 310 to 360 in the Sluiceway. Northwest winds blow the water of the Sluiceway out into the lake, where it travels eastward across the intake of the Mt. Clemens water works

Table 2. Conductivities and Residues of Surface Waters

Sample No.	Date Collected (1962)	Location	18°C Cond (μmhos/cm)	25°C Cond (μmhos/cm)	Total Residue (ppm)	Filterable Residue (ppm)
002	Oct. 17	In Clinton River	585	679	412	398
017	Oct. 19	In Black Creek	495	573	355	331
058	Nov. 14	Along Huron Point:				
		At Front Range Light (FRL) in				
036	Nov. 14	Black Creek, at water's edge	478	554	334	300
		50 yds. SE of FRL, at water's edge	402	466	282	251
034	Nov. 14	100 yds. SE of FRL, at water's edge	378	439	276	237
035	Nov. 14	150 yds. SE of FRL, at water's edge	353	409	262	223
051	Nov. 14	200 yds. SE of FRL, at water's edge	351	407	261	219
052	Nov. 14	250 yds. SE of FRL, at water's edge	347	402		219
053	Nov. 14	300 yds. SE of FRL, at water's edge	344	399	261	229
054	Nov. 14	350 yds. SE of FRL, 50 ft. from shore	331	384	256	216
055	Nov. 14	400 yds. SE of FRL, 20 ft. from shore	350	406	253	228
057	Nov. 14	450 yds. SE of FRL, 10 ft. from shore, (almost at tip of Pt. Huron)	354	410	262	226
		In Lake St. Clair:				
056	Nov. 14	50 ft. off shore near west end of Metropolitan Beach				
008	Oct. 18	SE of Huron Point	203	235	273	126
009	Oct. 18	At end of SE Bend Cutoff Channel	185.5	215	139	120
			185	214	126	117
		In St. Clair River:				
010	Oct. 18	In SE Bend Cutoff Channel	185	214	124	118
011	Oct. 18	At Junction of North and South Channels	181	210	137	115

and on alongshore to Metropolitan Beach.

Water-Quality at Metropolitan Beach

The results of bacteriological tests on water samples at the Beach, for the summers of 1961, 1962, and 1963, were provided by Mr. Pompo. These data were used in trying to ascertain whether the opening of the Southeast Bend Cutoff Channel, and the apparent greater proportion of St. Clair River water in the main lake basin, were capable of causing improved water quality at Metropolitan Beach.

From this study we are forced to the conclusion that the water quality at the Beach is so directly affected by local sources of poor water that improvement of main-basin water cannot be expected to improve water quality at the Beach.

Three local sources of poor-quality water are Black Creek, the canals of Stella Mare and the Clinton River Sluiceway.

Under the right wind each of these sources will discharge a slug of damaged water. Three or four hours of wind off the land are worse than a long-continued wind, for the first leaves the slug in the alongshore water while the latter blows it far out into the lake.

Whether one of these slugs reaches the Beach depends upon the direction of the wind that arises after the wind which caused the discharge of the slug.

The degree to which the arrival of a slug will affect the Beach water-quality depends upon the strength of the wind that brings the slug to the Beach. High winds cause more turbulence and mixing; gentle breezes can bring in essentially undiluted slugs.

It should be noted that Metropolitan Beach is situated between sources of poor water and that either eastward or westward alongshore current could bring in a low-quality slug after it has been pushed out into the alongshore water.

Winds from the north and northwest may be expected to push water out of Black Creek and Stella Mare. Northwest winds blowing along its length will push water out of the Sluiceway. Northeast and east winds (through pressure into the Anchor Bay connections of the canals east of Black Creek) also appear able to cause discharge of Black Creek. Winds from the southeast, south, and southwest bring better-quality open-lake water to the Beach, but they will also bring in slugs of poor water if the previous wind has caused slugs to be discharged into the alongshore water.

Bacteriological data from the Sluiceway and Stella Mare are not available, but there is no reason to expect that these waters are improving in quality.

The water sample data from Metropolitan Beach show increasing numbers of high counts in the Black Creek system from 1961 to 1963.

It is noted that none of the local sources of low quality water are under the control of the Authority and that the nearest of these, Black Creek, is worsening in water quality.

Chemical Levels in Lake St. Clair

Single samples of lake water, collected on 3 May 1962, were analyzed for content of phosphorus, Kjeldahl nitrogen, and nitrate nitrogen. The results were as follows:

Total phosphorus	119 parts per billion
K-nitrogen	0.50 parts per million
NO ₃ -nitrogen	0.35 " " "

Prof. Clair N. Sawyer on page 125 of his paper "Fertilization of Lakes by Agricultural and Urban Drainage" in Volume 61, Number 2, of the Journal of the New England Water Works Association in 1947, found that nuisance blooms of algae could be expected in lakes whose level of inorganic phosphorus exceeds 0.01 part per million. The 119 parts per billion of phosphorus in Lake St. Clair is equivalent to 0.119 parts per million or ten times the level at which algal nuisance can be expected.

Sawyer also found that inorganic nitrogen in excess of 0.30 parts per million could be expected to produce algal nuisances. Lake St. Clair, with 0.35 parts per million of nitrate-nitrogen (to which should be added undetermined amounts of nitrite-nitrogen and ammonia-nitrogen), is in excess of this critical nutrient level also.

"Algal nuisance" as used above means troublesome and expensive problems of taste and odor in public water supplies resulting from super-abundant growth of the microscopic algae in the water.

The fantastic taste-and-odor problems being battled by the Mt. Clemens water works are abundant proof that Lake St. Clair is over-fertilized and possessed of real algal nuisances.

Rooted aquatic plants are not included in the usual usage of the term "algal nuisance," but these plants need the same mineral nutrients as do the microscopic algae and the excessive abundance of the ribbon-grass water weed is also a result of the highly-fertile condition of Lake St. Clair.

ACKNOWLEDGEMENTS

We are enduringly grateful to all the personnel of the Authority for their unfailing and pleasant cooperation. Especial thanks are tendered to Mr. Hallenbeck, Mr. Pompo, and Mr. Peldo; these gentlemen have cheerfully made information, men, and equipment available even at times when they must have been inconvenienced thereby. If we have succeeded a substantial share of credit is due them.